

CLAIMS

What is claimed is:

1. A bubble cap comprising:
a riser having a top;
a cap having a bottom and at least one side slit, the cap disposed in relation to the riser
such that a fluid flows in a space between the riser and the cap; and
a divider disposed in the space, and extending to a length at least 50% of a distance
measured between the top of the riser and the bottom of the cap.
2. The bubble cap of claim 1 wherein the length of the divider is at least 70% of the distance
between the top of the riser and the bottom of the cap.
3. The bubble cap of claim 1 wherein the length of the divider is at least 90% of the distance
between the top of the riser and the bottom of the cap.
4. The bubble cap of claim 1 wherein the length of the divider is 100% of the distance
between the top of the riser and the bottom of the cap.
5. The bubble cap of claim 1 wherein the divider is attached to the riser.
6. The bubble cap of claim 1 wherein the divider is attached to the cap.
7. The bubble cap of claim 1 wherein the divider is attached to both the riser and the cap.
8. The bubble cap of claim 1 wherein the bubble cap has at least two dividers.
9. The bubble cap of claim 1 wherein the bubble cap has at least three dividers.
10. The bubble cap of claim 1 wherein the bubble cap has at least six dividers.
11. The bubble cap of claim 1, further comprising a swirl director attached to the riser.
12. A mixing device having a plurality of bubble caps according to claim 1.

WO 02/051530 A1



Published:

- with international search report
- with amended claims

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

13. A mixing device having a bubble cap of claim 1 wherein the bubble cap, having at least one slot, is positioned with respect to a distribution plate and the bottom of the cap is positioned at least 1.5 inches from the distribution plate.
14. A bubble cap, comprising:
5 a cap with at least one slot and a riser configured to provide the cap with a skirt height of no less than 1.5 inches.
15. The bubble cap of claim 14, wherein the skirt height is no less than 2.5 inches.
16. The bubble cap of claim 14, wherein the skirt height is no less than 4 inches.
17. The bubble cap of claim 14 wherein the cap has a side that includes at least three slots.
- 10 18. The bubble cap of claim 14, wherein the slot has a length of at least 2.5 inches.
19. The bubble cap of claim 14, wherein the slot has a length of at least 3.5 inches.
20. The bubble cap of claim 14, wherein the slot has a length of at least 5 inches.
21. A distribution device comprising:
a plurality of flow-redirecting vanes;
15 an upper plate;
a lower plate, the plates disposed in relation to the vanes such that a fluid flows in a space between the plates and the passageways formed by the vanes; and
a distribution tray, disposed below the lower plate.
22. The distribution device of claim 16 wherein the flow-redirecting vanes are chevron-type
20 vanes.
23. The distribution device of claim 16 wherein the distribution tray is a perforated plate.
24. The distribution device of claim 16 wherein the distribution tray is a bubble cap tray.
25. The distribution device of claim 16 wherein the distribution tray is a riser tray.

**[Received by the International Bureau on 20 August 2001 (20.08.01):
original claims 1, 14, 21-25 replaced by amended claims (2 pages)]**

1. A bubble cap comprising:
a riser having a top;
a cap having a bottom and at least one side slit, the cap disposed in relation to the riser such that a liquid fluid and a gaseous fluid flow co-currently upwardly in a space between the riser and the cap; and
a divider disposed in the space, and extending to a length at least 50% of a distance measured between the top of the riser and the bottom of the cap.
2. The bubble cap of claim 1 wherein the length of the divider is at least 70% of the distance between the top of the riser and the bottom of the cap.
3. The bubble cap of claim 1 wherein the length of the divider is at least 90% of the distance between the top of the riser and the bottom of the cap.
4. The bubble cap of claim 1 wherein the length of the divider is 100% of the distance between the top of the riser and the bottom of the cap.
5. The bubble cap of claim 1 wherein the divider is attached to the riser.
6. The bubble cap of claim 1 wherein the divider is attached to the cap.
7. The bubble cap of claim 1 wherein the divider is attached to both the riser and the cap.
8. The bubble cap of claim 1 wherein the bubble cap has at least two dividers.
9. The bubble cap of claim 1 wherein the bubble cap has at least three dividers.
10. The bubble cap of claim 1 wherein the bubble cap has at least six dividers.
11. The bubble cap of claim 1, further comprising a swirl director attached to the riser.
12. A mixing device having a plurality of bubble caps according to claim 1.
13. A mixing device having a bubble cap of claim 1 wherein the bubble cap, having at least one slot, is positioned with respect to a distribution plate and the bottom of the cap is positioned at least 1.5 inches from the distribution plate.

14. A bubble cap, comprising:
a cap with at least one slot and a riser configured to provide the cap with a skirt height of no less than 1.5 inches, disposed such that a liquid fluid and a gaseous fluid flow co-currently upwardly in a space between the riser and the cap.
15. The bubble cap of claim 14, wherein the skirt height is no less than 2.5 inches.
16. The bubble cap of claim 14, wherein the skirt height is no less than 4 inches.
17. The bubble cap of claim 14 wherein the cap has a side that includes at least three slots.
18. The bubble cap of claim 14, wherein the slot has a length of at least 2.5 inches.
19. The bubble cap of claim 14, wherein the slot has a length of at least 3.5 inches.
20. The bubble cap of claim 14, wherein the slot has a length of at least 5 inches.
21. A distribution device comprising:
a plurality of flow-redirecting vanes,
an upper plate having at least one fluid inlet orifice;
a lower plate, the plates disposed in relation to the vanes such that a fluid flows outwardly through a space between the plates and discharging through a fluid outlet orifice defined by the plates and the vanes; and
a distribution tray, disposed below the lower plate.
22. The distribution device of claim 21 wherein the flow-redirecting vanes are chevron-type vanes.
23. The distribution device of claim 21 wherein the distribution tray is a perforated plate.
24. The distribution device of claim 21 wherein the distribution tray is a bubble cap tray.
25. The distribution device of claim 21 wherein the distribution tray is a riser tray.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: SANDRA P. THOMPSON
FISH & ASSOCIATES, LLP
1440 N. HARBOR BLVD.
SUITE 706
FULLERTON, CA 92835

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing
(day/month/year)

26 SEP 2001

Applicant's or agent's file reference

325.144-PCT

IMPORTANT NOTIFICATION

International application No.

PCT/US01/13436

International filing date (day/month/year)

24 APRIL 2001

Priority Date (day/month/year)

21 DECEMBER 2000

Applicant

FLUOR CORPORATION

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US

Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231

Facsimile No. (703) 305-3250

Authorized officer

SCOTT BUSHEY

Telephone No. (703) 308-3581

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 325.144-PCT	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US01/13436	International filing date (day/month/year) 24 APRIL 2001	Priority date (day/month/year) 21 DECEMBER 2000
International Patent Classification (IPC) or national classification and IPC IPC(7): B01F 3/04 and US Cl.: 261/110, 113, 114.2		
Applicant FLUOR CORPORATION		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets.

☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability, citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 22 AUGUST 2001	Date of completion of this report 10 SEPTEMBER 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer SCOTT BUSHEY <i>Aug 24/01</i>
Facsimile No. (703) 305-3230	Telephone No. (703) 308-3581

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/US01/13436

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed☒ the description:

pages 1-11 , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____

☒ the claims:

pages NONE , as originally filed
pages NONE , as amended (together with any statement) under Article 19
pages 12 AND 13 , filed with the demand
pages NONE , filed with the letter of _____

☒ the drawings:

pages 1-5 , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____

☒ the sequence listing part of the description:

pages NONE , as originally filed
pages NONE , filed with the demand
pages NONE , filed with the letter of _____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language _____ which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in printed form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

- ☒ the description, pages NONE
☒ the claims, Nos. NONE
☒ the drawings, sheets/fig NONE

5. ☐ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

**Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/US01/13436

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. statement**

Novelty (N)

Claims	<u>1-25</u>	YES
Claims	<u>NONE</u>	NO

Inventive Step (IS)

Claims	<u>1-25</u>	YES
Claims	<u>NONE</u>	NO

Industrial Applicability (IA)

Claims	<u>1-25</u>	YES
Claims	<u>NONE</u>	NO

2. citations and explanations (Rule 70.7)

Claims 1-25 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest co-current flow of liquid and gaseous phases between the riser and cap structure of the bubbles caps recited by amended claims 1-20. Further, the prior art does not teach or fairly suggest the distribution device as recited by amended independent claim 21 and thus the dependent claims 22-25.

Claims 1-25 meet the criteria set out in PCT Article 33(4) since the claimed inventions are applicable to the fractional distillation industry.

----- NEW CITATIONS -----
NONE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/13436

A. CLASSIFICATION OF SUBJECT MATTER IPC(7) :B01F 3/04 US CL :261/110, 113, 114.2 According to International Patent Classification (IPC) or to both national classification and IPC																								
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 261/97, 110, 113, 114.2 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched NONE Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) NONE																								
C. DOCUMENTS CONSIDERED TO BE RELEVANT																								
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																						
X --- Y	US 1,711,656 A (RISDON) 07 May 1929, figs. 3 and 5.	1,6,8,12 ----- 2-5,7,9,10,13- 20,23-25																						
X --- Y	FR 874,509 A (I.G. FARBENINDUSTRIE AKTIENGESSELLSCHAFT) 10 August 1942, fig. 3.	21 ----- 22-25																						
A	PSC BUBBLE CAPS AND RISERS, The Pressed Steel Co., Wilkes-Barre, PA, 1955, Bulletin No. 22, design no. 12.	1-20																						
X --- Y	US 5,152,967 A (ROSSETTI et al) 06 October 1992, figs. 1,2,4,5.	21 ----- 22-25																						
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.																								
<table border="0"><tr><td>* Special categories of cited documents:</td><td>*T</td><td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td></tr><tr><td>*A</td><td>document defining the general state of the art which is not considered to be of particular relevance</td><td></td></tr><tr><td>*B</td><td>earlier document published on or after the international filing date</td><td>*X</td><td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td></tr><tr><td>*L</td><td>document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td><td>*Y</td><td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td></tr><tr><td>*O</td><td>document referring to an oral disclosure, use, exhibition or other means</td><td>*Z</td><td>document member of the same patent family</td></tr><tr><td>*P</td><td>document published prior to the international filing date but later than the priority date claimed</td><td></td><td></td></tr></table>			* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	*A	document defining the general state of the art which is not considered to be of particular relevance		*B	earlier document published on or after the international filing date	*X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	*L	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	*O	document referring to an oral disclosure, use, exhibition or other means	*Z	document member of the same patent family	*P	document published prior to the international filing date but later than the priority date claimed		
* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention																						
*A	document defining the general state of the art which is not considered to be of particular relevance																							
*B	earlier document published on or after the international filing date	*X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone																					
*L	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art																					
*O	document referring to an oral disclosure, use, exhibition or other means	*Z	document member of the same patent family																					
*P	document published prior to the international filing date but later than the priority date claimed																							
Date of the actual completion of the international search 05 JUNE 2001		Date of mailing of the international search report 21 JUN 2001																						
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230		Authorized officer SCOTT BUSHEY <i>Scott Bushey</i> Telephone No. (703) 308-3581																						

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/13436

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,098,965 A (JACOBS et al) 08 August 2000, figs. 16-19.	11

Practitioner's Docket No. 325.144-PCT

#14
20

IN THE UNITED STATES INTERNATIONAL PRELIMINARY
EXAMINATION AUTHORITY (IPEA/US)

PCT/US01/13436	24 April 2001 (24/04/01)	21 December 2000 (21/12/00)
International Application Number	International Filing Date	International Earliest Priority Date

Title of Invention: **Methods And Apparatus For Mixing Fluids**
Applicant: **Fluor Corporation**

Box PCT/IPEA
Assistant Commissioner for Patents
Washington, D.C. 20231

PCT ARTICLE 34 AMENDMENTS

1. Applicant herewith submits replacement sheets(s) number(ed) 12 to replace sheet(s) number(ed) 12 originally filed for this application.
2. In respect of each claim appearing in the international application based on the replacement sheets submitted herewith, and in accordance with PCT Section 205, the following claim(s) is/are:
 - (i) unchanged: claim(s) 2-25
 - (ii) cancelled: claim(s) 0
 - (iii) new: claim(s) 1
 - (iv) replacement of one or more claims as filed, as follows: 0
 - (v) the result of the division of one or more claims as filed, as follows: 0

CERTIFICATION UNDER 37 C.F.R. 1.10*
(Express Mail label number is *mandatory*.)
(Express Mail Certification is *optional*.)

I hereby certify that this paper and the documents referred to as being transmitted therewith are being deposited with the United States Postal Service on this date October 26, 2001 in an envelope as "Express Mail Post Office to Addressee" Mailing Label Number EL717595325US addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.


Sara L. Geer

Dear Sir:

Claim 1 has been amended to correct a typographical error. Please replace original page 12 with substitute pages 12. There is no new matter added by virtue of the amendment.


In the Claims

Claim 1: The word "slit" has been changed to "slot".

As stated above, all the amendments, including those made to the claims are merely typographical and/or grammatical corrections and these amendments do not contain any new matter.

Date: 26 Oct 2001

Fish & Associates, LLP
1440 N. Harbor Blvd.
Suite 706
Fullerton, CA 92835
Tel: (714) 449-2337
Fax: (714) 449-2339


Robert D. Fish
Reg. No. 33,880

CLAIMS

What is claimed is:

1. A bubble cap comprising:
a riser having a top;
a cap having a bottom and at least one side slit, the cap disposed in relation to the riser such that a liquid fluid and a gaseous fluid flow co-currently upwardly in a space between the riser and the cap; and
a divider disposed in the space, and extending to a length at least 50% of a distance measured between the top of the riser and the bottom of the cap.
2. The bubble cap of claim 1 wherein the length of the divider is at least 70% of the distance between the top of the riser and the bottom of the cap.
3. The bubble cap of claim 1 wherein the length of the divider is at least 90% of the distance between the top of the riser and the bottom of the cap.
4. The bubble cap of claim 1 wherein the length of the divider is 100% of the distance between the top of the riser and the bottom of the cap.
5. The bubble cap of claim 1 wherein the divider is attached to the riser.
6. The bubble cap of claim 1 wherein the divider is attached to the cap.
7. The bubble cap of claim 1 wherein the divider is attached to both the riser and the cap.
8. The bubble cap of claim 1 wherein the bubble cap has at least two dividers.
9. The bubble cap of claim 1 wherein the bubble cap has at least three dividers.
10. The bubble cap of claim 1 wherein the bubble cap has at least six dividers.
11. The bubble cap of claim 1, further comprising a swirl director attached to the riser.
12. A mixing device having a plurality of bubble caps according to claim 1.
13. A mixing device having a bubble cap of claim 1 wherein the bubble cap, having at least one slot, is positioned with respect to a distribution plate and the bottom of the cap is positioned at least 1.5 inches from the distribution plate.

PATENT COOPERATION TREATY

#15

PCT

NOTIFICATION CONCERNING
AMENDMENTS OF THE CLAIMS(PCT Rule 62 and
Administrative Instructions, Section 417)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as International Preliminary Examining Authority

Date of mailing (day/month/year)

21 November 2001 (21.11.01)

International application No.

PCT/US01/13436

International filing date (day/month/year)

24 April 2001 (24.04.01)

Applicant

FLUOR CORPORATION et al

The International Bureau hereby transmits a copy of the amendments to the claims under Article 19 together with any accompanying statement (Rule 62).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Ghislaine BORNET

Telephone No. (41-22) 338.83.38

IN THE INTERNATIONAL BUREAU (WIPO)

International Application Number	International Filing Date	International Earliest Priority Date
PCT/US01/13436	24 April 2001	21 Dec 2000

Title of Invention: **Methods and Apparatus for Mixing Fluids**
Applicant: **Fluor Corporation**

International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20
Switzerland

LETTER FOR PCT ARTICLE 19
(PCT SECTION 205)

1. Applicant herewith submits replacement sheets(s) number(ed) 12-13 to replace sheet(s) number(ed) 12-13 originally filed for this application.

2. In respect of each claim appearing in the international application based on the replacement sheets submitted herewith, and in accordance with PCT Section 205, the following claim(s) is/are:

- (i) unchanged: claim(s) 0
- (ii) cancelled: claim(s) 0
- (iii) new: claim(s) 0
- (iv) replacement of one or more claims as filed, as follows: **1, 14, 21-25**
- (v) the result of the division of one or more claims as filed, as follows: **0**

Dear Sir:

The Search Report dated 21 June 2001 designated four references as being relevant to patentability. In response, claims 1, 14 and 21-25 have been revised. The revised claim and references are addressed below seriatim. Technical corrections to the specification are identified here, and will be made in conjunction with the Chapter II filing.

CLAIMS

What is claimed is:

1. A bubble cap comprising:
a riser having a top;
a cap having a bottom and at least one side slit, the cap disposed in relation to the riser
~~such that a liquid fluid and a gaseous fluid flow co-currently upwardly in a~~
space between the riser and the cap; and
a divider disposed in the space, and extending to a length at least 50% of a distance
measured between the top of the riser and the bottom of the cap.
2. The bubble cap of claim 1 wherein the length of the divider is at least 70% of the
distance between the top of the riser and the bottom of the cap.
3. The bubble cap of claim 1 wherein the length of the divider is at least 90% of the
distance between the top of the riser and the bottom of the cap.
4. The bubble cap of claim 1 wherein the length of the divider is 100% of the distance
between the top of the riser and the bottom of the cap.
5. The bubble cap of claim 1 wherein the divider is attached to the riser.
6. The bubble cap of claim 1 wherein the divider is attached to the cap.
7. The bubble cap of claim 1 wherein the divider is attached to both the riser and the cap.
8. The bubble cap of claim 1 wherein the bubble cap has at least two dividers.
9. The bubble cap of claim 1 wherein the bubble cap has at least three dividers.
10. The bubble cap of claim 1 wherein the bubble cap has at least six dividers.
11. The bubble cap of claim 1, further comprising a swirl director attached to the riser.
12. A mixing device having a plurality of bubble caps according to claim 1.
13. A mixing device having a bubble cap of claim 1 wherein the bubble cap, having at
least one slot, is positioned with respect to a distribution plate and the bottom of the
cap is positioned at least 1.5 inches from the distribution plate.

14. A bubble cap, comprising:
a cap with at least one slot and a riser configured to provide the cap with a skirt height of no less than 1.5 inches, disposed such that a liquid fluid and a gaseous fluid flow co-currently upwardly in a space between the riser and the cap.
15. The bubble cap of claim 14, wherein the skirt height is no less than 2.5 inches.
16. The bubble cap of claim 14, wherein the skirt height is no less than 4 inches.
17. The bubble cap of claim 14 wherein the cap has a side that includes at least three slots.
18. The bubble cap of claim 14, wherein the slot has a length of at least 2.5 inches.
19. The bubble cap of claim 14, wherein the slot has a length of at least 3.5 inches.
20. The bubble cap of claim 14, wherein the slot has a length of at least 5 inches.
21. A distribution device comprising:
a plurality of flow-redirecting vanes,
an upper plate having at least one fluid inlet orifice;
a lower plate, the plates disposed in relation to the vanes such that a fluid flows outwardly through a space between the plates and discharging through a fluid outlet orifice defined by the plates and the vanes; and
a distribution tray, disposed below the lower plate.
22. The distribution device of claim 21 wherein the flow-redirecting vanes are chevron-type vanes.
23. The distribution device of claim 21 wherein the distribution tray is a perforated plate.
24. The distribution device of claim 21 wherein the distribution tray is a bubble cap tray.
25. The distribution device of claim 21 wherein the distribution tray is a riser tray.

The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are competent, with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below:

IPEA/ US**PCT****CHAPTER II****DEMAND**

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority US only**IPEA/US 22 AUG 2001**Identification of IPEA 145

Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION

Applicant's or agent's file reference

325.144-PCT

International application No.

International filing date (day/month/year)

(Earliest) Priority date (day/month/year)

PCT/US01/13436**24 April 2001****21 December 2000****(24.04.01)****(21.12.00)**

Title of invention

Methods and Apparatus for Mixing Fluids**Box No. II APPLICANT(S)**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

Telephone No.:

Fluor Corporation**949-349-6976****One Enterprise Drive**

Facsimile No.:

Aliso Viejo, CA 92656-2606**949-349-3961****USA ▲ US**

Teleprinter No.:

State (that is, country) of nationality:

State (that is, country) of residence:

US**US**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

JACOBS, Garry E.**Fluor Corporation****One Enterprise****Aliso Viejo, CA 92656-2606****USA ▲ US**

State (that is, country) of nationality:

State (that is, country) of residence:

US**US**

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

STUPIN, Steven W.**Fluor Corporation****One Enterprise Drive****Aliso Viejo, CA 92656-2606****USA ▲ US**

State (that is, country) of nationality:

State (that is, country) of residence:

US**US**☒ Further applicants are indicated on a continuation sheet.

Continuation of Box No. II APPLICANT(S)

If none of the following sub-boxes is used, this sheet should not be included in the demand.

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

MILLIKEN, Adam S.
Fluor Corporation
One Enterprise Drive
Aliso Viejo, CA 92656-2606
USA ▲ US

State (that is, country) of nationality:

US

State (that is, country) of residence:

US

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

State (that is, country) of nationality:

State (that is, country) of residence:

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

State (that is, country) of nationality:

State (that is, country) of residence:

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

State (that is, country) of nationality:

State (that is, country) of residence:

☐ Further applicants are indicated on another continuation sheet.

▲ corrected By
Ipea/US

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCEThe following person is ☒ agent ☐ common representativeand ☒ has been appointed earlier and represents the applicant(s) also for international preliminary examination.☐ is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.☐ is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.Name and address: (Family name followed by given name; for a legal entity, full official designation.
The address must include postal code and name of country.)

THOMPSON, Sandra Poteat

Fish & Associates, LLP

1440 N. Harbor Blvd.

Suite 706

Fullerton, CA 92835

USA 

Telephone No.:

714-449-2337

Facsimile No.:

714-449-2339

Teleprinter No.:

☐ Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.**Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION****Statement concerning amendments:***

1. The applicant wishes the international preliminary examination to start on the basis of:

☒ the international application as originally filedthe description ☒ as originally filed
☐ as amended under Article 34the claims ☐ as originally filed
☒ as amended under Article 19 (together with any accompanying statement)
☐ as amended under Article 34the drawings ☒ as originally filed
☐ as amended under Article 342. ☐ The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.3. ☐ The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). (This check-box may be marked only where the time limit under Article 19 has not yet expired.)

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination:

English

☒ which is the language in which the international application was filed.☐ which is the language of a translation furnished for the purposes of international search.☐ which is the language of publication of the international application.☐ which is the language of the translation (to be) furnished for the purposes of international preliminary examination.**Box No. V ELECTION OF STATES**

The applicant hereby elects all eligible States (that is, all States which have been designated and which are bound by Chapter II of the PCT)

excluding the following States which the applicant wishes not to elect:

Corrected by I-PEA/US

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:

- | | | | |
|--|---|---|----------|
| 1. translation of international application | : | 0 | sheets |
| 2. amendments under Article 34 | : | 2 | 0 sheets |
| 3. copy (or, where required, translation) of amendments under Article 19 | : | 2 | sheets |
| 4. copy (or, where required, translation) of statement under Article 19 | : | 3 | sheets |
| 5. letter | : | 5 | 0 sheets |
| 6. other (specify) | : | 0 | sheets |

For International Preliminary Examining Authority use only

- | received | not received |
|-------------------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> |

The demand is also accompanied by the item(s) marked below:

- | | |
|--|---|
| 1. <input checked="" type="checkbox"/> fee calculation sheet | 4. <input type="checkbox"/> statement explaining lack of signature |
| 2. <input type="checkbox"/> separate signed power of attorney | 5. <input type="checkbox"/> nucleotide and or amino acid sequence listing in computer readable form |
| 3. <input type="checkbox"/> copy of general power of attorney; reference number, if any: | 6. <input type="checkbox"/> other (specify): |

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

Sandra Poteat Thompson Sandra Poteat Thompson, Agent

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND: JC20 Rec'd PCT/PTO 2 2 AUG 2001

2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):

- | | |
|--|---|
| 3. <input type="checkbox"/> The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. | <input type="checkbox"/> The applicant has been informed accordingly. |
| 4. <input type="checkbox"/> The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5. | |
| 5. <input type="checkbox"/> Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82. | |

For International Bureau use only

Demand received from IPEA on:

Corrected to IPEA/US
deleted by IPEA/US

PCT

FEE CALCULATION SHEET

Annex to the Demand for international preliminary examination

International application No. PCT/US01/13436 Applicant's or agent's file reference 325.144-PCT	For International Preliminary Examining Authority use only Date stamp of IPEA IP/EA/US 42 AUG 2001
Applicant FLUOR CORPORATION, et al.	
Calculation of prescribed fees	
1. Preliminary examination fee	<div style="border: 1px solid black; padding: 2px; display: inline-block;">490.00</div> <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">P</div>
2. Handling fee (<i>Applicants from certain States are entitled to a reduction of 75% of the handling fee. Where the applicant is (or all applicants are) so entitled, the amount to be entered at H is 25% of the handling fee.</i>)	<div style="border: 1px solid black; padding: 2px; display: inline-block;">137.00</div> <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-left: 10px;">H</div>
3. Total of prescribed fees Add the amounts entered at P and H and enter total in the TOTAL box.....	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> USD 627.00 <hr/> TOTAL </div>
Mode of Payment	
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <input type="checkbox"/> authorization to charge deposit account with the IPEA (see below) </div> <div style="width: 45%;"> <input type="checkbox"/> cash </div> </div> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <input checked="" type="checkbox"/> cheque </div> <div style="width: 45%;"> <input type="checkbox"/> revenue stamps </div> </div> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <input type="checkbox"/> postal money order </div> <div style="width: 45%;"> <input type="checkbox"/> coupons </div> </div> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <input type="checkbox"/> bank draft </div> <div style="width: 45%;"> <input type="checkbox"/> other (specify): </div> </div>	
Deposit Account Authorization (<i>this mode of payment may not be available at all IPEAs</i>) The IPEA/ <u>US</u> <input type="checkbox"/> is hereby authorized to charge the total fees indicated above to my deposit account. <input checked="" type="checkbox"/> (<i>this check-box may be marked only if the conditions for deposit accounts of the IPEA so permit</i>) is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account.	
500341 Deposit Account Number	22/08/2001 August 22, 2001 Date (day/month/year)
Signature <i>Sandra Thompson</i>	

Original (for SUBMISSION) - printed on 24.04.2001 02:03:40 PM

0	For receiving Office use only	
0-1	International Application No.	127051/1343A
0-2	International Filing Date	24 APR 2001 (24.04.01)
0-3	Name of receiving Office and "PCT International Application"	PCT APPL
0-4	Form - PCT/RO/101 PCT Request	
0-4-1	Prepared using	PCT-EASY Version 2.91 (updated 01.01.2001)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	United States Patent and Trademark Office (USPTO) (RO/US)
0-7	Applicant's or agent's file reference	325.144-PCT
I	Title of invention	METHODS AND APPARATUS FOR MIXING FLUIDS
II	Applicant	
II-1	This person is:	applicant only
II-2	Applicant for	all designated States except US
II-4	Name	FLUOR CORPORATION
II-5	Address:	One Enterprise Drive Aliso Viejo, CA 92656-2606 United States of America
II-6	State of nationality	US
II-7	State of residence	US
II-8	Telephone No.	949-349-6976
II-9	Facsimile No.	949-349-3961
III-1	Applicant and/or inventor	
III-1-1	This person is:	applicant and inventor
III-1-2	Applicant for	US only
III-1-4	Name (LAST, First)	JACOBS, Garry, E.
III-1-5	Address:	Fluor Corporation One Fluor Daniel Drive Aliso Viejo, CA 92656-2606 United States of America
III-1-6	State of nationality	US
III-1-7	State of residence	US

PCT REQUEST

325.144-PCT

Original (for SUBMISSION) - printed on 24.04.2001 02:03:40 PM

III-2	Applicant and/or inventor	
III-2-1	This person is:	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	STUPIN, Steven, W.
III-2-5	Address:	Fluor Corporation One Fluor Daniel Drive Aliso Viejo, CA 92656-2606 United States of America
III-2-6	State of nationality	US
III-2-7	State of residence	US
III-3	Applicant and/or inventor	
III-3-1	This person is:	applicant and inventor
III-3-2	Applicant for	US only
III-3-4	Name (LAST, First)	MILLIKEN, Adam, S.
III-3-5	Address:	Fluor Corporation One Fluor Daniel Drive Aliso Viejo, CA 92656-2606 United States of America
III-3-6	State of nationality	US
III-3-7	State of residence	US
IV-1	Agent or common representative; or address for correspondence The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name (LAST, First)	FISH, Robert, D.
IV-1-2	Address:	Fish & Associates, LLP 1440 N. Harbor Blvd. Suite 706 Fullerton, CA 92835 United States of America
IV-1-3	Telephone No.	714-449-2337
IV-1-4	Facsimile No.	714-449-2339
IV-1-5	e-mail	rfish@fishandassociates.com

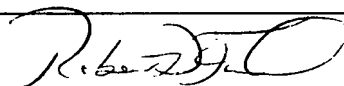
PCT REQUEST

325.144-PCT

Original (for SUBMISSION) - printed on 24.04.2001 02:03:40 PM

V	Designation of States	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	<p>AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT</p> <p>EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT</p> <p>EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR and any other State which is a Contracting State of the European Patent Convention and of the PCT</p> <p>OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT</p>
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	<p>AE AG AL AM AT (patent and utility model) AU AZ BA BB BG BR BY BZ CA CH&LI CN CR CU CZ (patent and utility model) DE (patent and utility model) DK (patent and utility model) DM DZ EE (patent and utility model) ES FI (patent and utility model) GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK (patent and utility model) SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW</p>
V-3	National Patent (States which have become party to the PCT after the issuance of this version of EASY)	All
V-5	Precautionary Designation Statement In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	Exclusion(s) from precautionary designations	NONE

Original (for SUBMISSION) - printed on 24.04.2001 02:03:40 PM

VI-1	Priority claim of earlier national application		
VI-1-1	Filing date	21 December 2000 (21.12.2000)	
VI-1-2	Number	60/257,414	
VI-1-3	Country	US	
VI-2	Priority document request		
	The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1	
VII-1	International Searching Authority Chosen	United States Patent and Trademark Office (USPTO) (ISA/US)	
VIII	Check list	number of sheets	electronic file(s) attached
VIII-1	Request	5	-
VIII-2	Description	11	-
VIII-3	Claims	2	-
VIII-4	Abstract	1	EZABST00.TXT
VIII-5	Drawings	7	-
VIII-7	TOTAL	26	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-18	Figure of the drawings which should accompany the abstract	2A	
VIII-19	Language of filing of the international application	English	
IX-1	Signature of applicant or agent		
IX-1-1	Name (LAST, First)	FISH, Robert, D.	

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(24.04.01)

10-1	Date of actual receipt of the purported international application	JO17 Rec'd PCT/PTO 24 APR 2001
10-2	Drawings:	
10-2-1	Received	
10-2-2	Not received	
10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/US
10-6	Transmittal of search copy delayed until search fee is paid	

PCT/03 01/13436

5/5

PCT REQUEST

325.144-PCT

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11-1	Date of receipt of the record copy by the International Bureau	
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PCT (ANNEX - FEE CALCULATION SHEET)

325.144-PCT

Original (for SUBMISSION) - printed on 24.04.2001 02:03:40 PM


(This sheet is not part of and does not count as a sheet of the international application)

0	For receiving Office use only			
0-1	International Application No.	PCT/US 01/13436		
0-2	Date stamp of the receiving Office	24 APR 2001 (24.04.01)		
0-4	Form - PCT/RO/101 (Annex) PCT Fee Calculation Sheet			
0-4-1	Prepared using	PCT-EASY Version 2.91 (updated 01.01.2001)		
0-9	Applicant's or agent's file reference	325.144-PCT		
2	Applicant	FLUOR CORPORATION, et al.		
12	Calculation of prescribed fees	fee amount/multiplier	total amounts (USD)	
12-1	Transmittal fee T	⇒	240	240
12-2	Search fee S	⇒	700	700
12-3	International fee			
	Basic fee			
	(first 30 sheets) b1	382		382
12-4	Remaining sheets	0		
12-5	Additional amount (X) 9			
12-6	Total additional amount b2	0		
12-7	b1 + b2 = B	382		382
12-8	Designation fees			
	Number of designations contained in international application	88		
12-9	Number of designation fees payable (maximum 6)	6		
12-10	Amount of designation fee (X) 82			
12-11	Total designation fees D	492		492
12-12	PCT-EASY fee reduction R	-117		117
12-13	Total International fee (B+D-R) I	⇒	757	757
12-14	Fee for priority document			
	Number of priority documents requested	1		
12-15	Fee per document (X) 15			
12-16	Total priority document fee P	⇒	15	15
12-17	TOTAL FEES PAYABLE (T+S+I+P)	⇒	1,712	1712
12-19	Mode of payment	cheque		
12-20	Deposit account instructions			
	The receiving Office:	United States Patent and Trademark Office (USPTO) (RO/US)		
12-20-2	is hereby authorized to charge any deficiency or credit any over-payment in the total fees indicated above to my deposit account	✓ <i>R. L. Smith</i>		
12-20-3	is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit account	✓ <i>R. L. Smith</i>		

PCT (ANNEX - FEE CALCULATION SHEET)

325.144-PCT

Original (for SUBMISSION) - printed on 24.04.2001 02:03:40 PM

12-21	Deposit account No.	500341
12-22	Date	24 April 2001 (24.04.2001)
12-23	Name and signature	FISH, Robert, D. 

VALIDATION LOG AND REMARKS

13-2-2	Validation messages States	Yellow! Additional national designation added: Obtain updated maintenance tables rather than using this field.
13-2-6	Validation messages Contents	Yellow! The power of attorney or a copy of the general power of attorney will need to be furnished unless all applicants sign the request form.

PCT

NO 01/13436
18 JUL 2007

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s)

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

Fluor Corporation
One Enterprise Drive
Aliso Viejo, CA 92656-2606
US

hereby appoints (appoint) the following person as:



agent



common representative

Name and address

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

FISH, Robert D.; ZOETEWEEY, David J.; THOMPSON, Sandra Poteat; FESSENMAIER, Martin
Fish & Associates, LLP
1440 N. Harbor Blvd.
Suite 706
Fullerton, CA 92835
USA

to represent the undersigned before



all the competent International Authorities



the International Searching Authority only



the International Preliminary Examining Authority only

in connection with any and all international applications filed by the undersigned with the following Office

USPTO

as receiving Office

and to make or receive payments on behalf of the undersigned.

Signatures of the applicant(s) (where there are several persons, each of them must sign; next to the signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power):

Lawrence N. Fisher

Lawrence N. Fisher, Senior Vice President

Date:

April 27, 2001

PCT/US01/13436
18 JUL 2001

PCT

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s)

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

JACOBS, Garry E.
Fluor Corporation, One Fluor Daniel Drive
Aliso Viejo, CA 92656-2606
USA

hereby appoints (appoint) the following person as:

☒ agent☐ common representative

Name and address

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

FISH, Robert D.; ZOETEWEE, David J.; THOMPSON, Sandra Poteat; FESSENMAIER, Martin
Fish & Associates, LLP
1440 N. Harbor Blvd.
Suite 706
Fullerton, CA 92835
USA

to represent the undersigned before

☒

all the competent International Authorities

☐

the International Searching Authority only

☐

the International Preliminary Examining Authority only

in connection with any and all international applications filed by the undersigned with the following Office

USPTO

as receiving Office

and to make or receive payments on behalf of the undersigned.

Signatures of the applicant(s) (where there are several persons, each of them must sign; next to the signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power):



Garry E. Jacobs, Applicant / Inventor

Date:

7/10/01

Form PCT/Model of general power of attorney (for several international applications)(July 1992)

PCT
PCT/US 01/13436
PCT/US 18 JUL 2007

PCT

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s):

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

STUPIN, Steven W.
Fluor Corporation, One Fluor Daniel Drive
Aliso Viejo, CA 92656-2606
USA

hereby appoints (appoint) the following person as:



agent



common representative

Name and address

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

FISH, Robert D.; ZOETEWEE, David J.; THOMPSON, Sandra Poteat; FESSENMAIER, Martin
Fish & Associates, LLP
1440 N. Harbor Blvd.
Suite 706
Fullerton, CA 92835
USA

to represent the undersigned before



all the competent International Authorities



the International Searching Authority only



the International Preliminary Examining Authority only

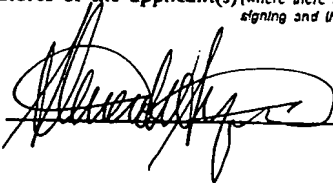
in connection with any and all international applications filed by the undersigned with the following Office

USPTO

as receiving Office

and to make or receive payments on behalf of the undersigned.

Signatures of the applicant(s) (where there are several persons, each of them must sign; next to the signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power):



Steven W. Stupin, Applicant / Inventor

Date:

7/16/2001

Form PCT/Model of general power of attorney (for several international applications)(July 1992)

PCT

PCT/US 01/13430
POUS 18 JUL 2001

GENERAL POWER OF ATTORNEY

(for several international applications filed under the Patent Cooperation Treaty)

(PCT Rule 90.5)

The undersigned person(s):

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

MILLIKEN, Adam S.
Fluor Corporation, One Fluor Daniel Drive
Aliso Viejo, CA 92656-2606
USA

hereby appoints (appoint) the following person as: ☒ agent ☐ common representative

Name and address

(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

FISH, Robert D.; ZOETWEY, David J.; THOMPSON, Sandra Poteat; FESSENMAIER, Martin
Fish & Associates, LLP
1440 N. Harbor Blvd.
Suite 706
Fullerton, CA 92835
USA

to represent the undersigned before

- ☒ all the competent International Authorities
☐ the International Searching Authority only
☐ the International Preliminary Examining Authority only

in connection with any and all international applications filed by the undersigned with the following Office

USPTO

as receiving Office

and to make or receive payments on behalf of the undersigned.

Signatures of the applicant(s) *(where there are several persons, each of them must sign; next to the signature, indicate the name of the person signing and the capacity in which the person signs, if such capacity is not obvious from reading this power);*

Adam S. Milliken

Adam S. Milliken, Applicant / Inventor

Date: 6/15/01

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Attorney Dkt No. 325.144-PCT

METHODS AND APPARATUS FOR MIXING FLUIDS

Field of The Invention

The field of the invention relates to fluid mixing and distribution.

5 Background of The Invention

Many commercial processes involve mixing of fluids, including especially catalytic reactors and large fractionation columns. Such mixing is not always a simple matter, especially where the fluid has multiple phases (such as liquids and gases/vapors), and where large volumes are being rapidly mixed. Numerous mixing apparatus are known, and some of these are
10 described in US 6098065 to *Jacobs et al.* (August 2000), which is incorporated herein by reference in its entirety. *Jacobs et al.* teach several improvements, some of which involve bubble caps spaced apart on a distribution plate.

Bubble caps generally comprise a riser and a cap, arranged such that a fluid flows upwards in a space between the cap and the riser, reverses direction and then flows downward
15 through a passageway in the riser. In the absence of swirl directors, the fluid flow path is thus generally in the shape of an inverted "U". Bubble caps are generally affixed to a distribution plate, and the passageway through the riser is confluent with a hole in the distribution plate. Bubble caps often contain a plurality of side slots that provide an entrance for the gas phase into the annular space between the riser and the cap. The gas entrains liquid present in the annular
20 space. See, for example, U.S. Patent No. 5,158,714 to *Shih et al.* (October 1992), which is herein incorporated in its entirety by reference.

There must be some mechanism for maintaining the position of the riser with respect to the cap. It is known to use cantilevered arms or other spacers for that purpose. See, for example, U.S. Patent Nos. 5,989,502 to *Nelson et al.* (November 1999) and 4,305,895 to *Heath et al.*
25 (December 1981), each of which is incorporated herein in its entirety by reference. In the past, such spacers have always been of minimal size to reduce cost and minimize any flow effects. Prior art spacers therefore exclusively serve a positioning function, and do not materially assist in either fluid flow or mixing.

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Skirt height has been shown to materially affect the fluid flow and mixing. See, for example, "Optimum Bubble-Cap Tray Design", Bolles, William L., a four part series in *Petroleum Processing*, Vol. 11, No.2, pp 65-80; Vol. 11, No.3, pp 82-95; Vol. 11, No.4, pp 72-79, Vol. 11, No.5, pp 109-120, which is incorporated herein in its entirety by reference. In this series of articles, Bolles presents a design methodology for bubble caps of the type commonly used in distillation columns. In such columns, the vapor flow is upward through the bubble cap tray and the liquid flow is transverse, across the bubble cap tray. Such flow is typically described as countercurrent flow. In the Bolles article, at Vol. 11, No.3, p.87, a skirt height of 0.5 inches to 1.5 inches is recommended, and there is a suggestion that greater skirt heights would be disadvantageous. There is certainly no teaching, suggestion, or motivation of which the current applicants are aware, for skirt heights greater than 1.5 inches.

Conversely, Ballard et al. (U.S. 3,218,249) teaches the use of bubble caps as a mixing and distribution means for the concurrent downflow of vapor and liquid. Ballard et al. teaches skirt heights of any distance "...above the distribution tray so long as the flow of gas through the downcomers is not sealed off; a reasonable range being from a level corresponding to practically no distance above the tray to a distance of about one foot thereabove." Ballard et al. further teaches that "...the liquid phase, disengaged from the vapor phase by gravity, fills up on tray to a level below the slot depth in the downcomer caps, such level being determined primarily by the gas flow rate per cap. It is, of course, necessary that some of the slot openings be exposed above the liquid surface to permit passage of vapor therethrough. Where the caps have no slots, the liquid level on the tray will be below the bottom rims of the caps for the same reason. Where unslotted caps are used, clearance between the bottom rim and the tray must be maintained to accommodate the passage of gas and liquid thereunder." Clearly, the skirt height dimensional range taught by Ballard, et al. applies specifically to an unslotted cap, because vapor flow through a slotted cap can not be blocked off by reducing the skirt height to practically no distance. There is no teaching of a specific dimensional range suitable for slotted bubble caps.

Shih, et al. (U.S. 5,158,714) teaches the use of a dispersion plate to improve the distribution of liquid exiting the riser. Gamborg, et al. (U.S. 5,942,162) teaches the use of a slotted bubble cap, modified such that the cap is non-concentric with the riser, to improve the uniformity of liquid distribution. Gamborg, et al. describe this modified bubble cap as a vapor

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lift tube, wherein the cap is called an upflow tube and the riser is called a downflow tube.

Nonetheless, the fluid flow path is the shape of an inverted "U", flowing first upward through the upflow tube and then downward through the downflow tube. Jacobs, et al. (U.S. 6,098,965) teaches the use of riser vanes and/or target plates to improve the distribution of liquid exiting the riser. Aside from the patents cited above, the current applicants are not aware of any other information in the public domain that discloses technological advances in the use of bubble caps as a mixing and distribution means for the concurrent downflow of vapor and liquid

Some systems that utilize bubble caps provide for rough distribution of fluids upstream of the bubble caps. A patent granted to *Stangeland, et al.* (U.S. 5,690,896 November 1997) describes an apparatus for rough distribution comprising a perforated plate located directly above the bubble cap tray. With this approach, the perforations must pass both the gas phase and liquid phase fluids. As a result, the prevailing liquid level on this tray may be quite low, thereby negatively impacting the quality of rough distribution. A patent granted to *Grott, et al.* (U.S. 5,837,208 November 1998) describes an apparatus for rough distribution consisting of a perforated tray surrounded by cylindrical wall. With this approach, the gas phase fluid can flow through the annular area between the perforated tray and the reactor wall, while the liquid phase fluid flows primarily through the perforations. One drawback of this approach is that the annularly downflowing gas phase fluid can disturb the liquid surface on the bubble cap tray, thereby negatively impacting the performance of the bubble cap tray. Finally, with both of the above approaches, the perforated trays restrict inspection and maintenance access to the bubble cap tray.

Thus, there is still a need for improved methods and apparatus for mixing and distributing fluids, including improvements to bubble cap trays and rough distribution mechanisms.

Summary of the Invention

In one aspect, the present invention provides devices and methods in which a bubble cap has a riser and a cap, separated by a divider that extends to a length at least 50% of a distance measured between the top of the riser and the bottom of the cap, this distance henceforth being referred to as the "riser/cap span". In preferred embodiments the divider is preferably at least

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70% of the riser/cap span, and more preferably at least 90% of the riser/cap span, . The divider may be attached to either or both the riser and the cap, and there may be two or more such dividers.

5 In another aspect, the present invention provides devices and methods in which the riser and cap cooperate to provide a skirt height suitable for the liquid volumetric rate passing through the tray. The portion of the riser and cap below the liquid surface acts as a hydraulic resistance to liquid crossflowing the tray. This hydraulic resistance results in a variation in the liquid depth on the tray. Higher liquid depths occur in the areas on the tray where the liquid has been introduced to the tray, while lower liquid depths occur in the areas on the tray where the liquid
10 has arrived by crossflow. These variations in the liquid depth are just as detrimental to the uniformity of liquid distribution as physical variations from levelness of the tray deck itself.

By increasing skirt height, the hydraulic resistance to liquid crossflow is reduced. The preferred skirt height for a specific application is dependent upon, among other things, the liquid volumetric rate passing through the tray. For low liquid rates, bubble caps having a skirt height
15 of no less than 1.5 inches is preferred. At higher liquid rates, bubble caps having a skirt height of at least 2.0 inches is more preferred, and at still higher liquid rates, bubble caps having a skirt height of at least 2.5 inches is more preferred. At very high liquid rates, as may be encountered in very large reactors, bubble caps having a skirt height of 3 inches or higher are contemplated.
20 The unusually high skirt heights are preferably achieved by using an especially long riser rather than using an especially short cap.

In yet another aspect, the present invention provides devices and methods in which chevron-type vanes and plates (e.g., mixing chamber floor and splash deck) cooperate to provide a rough distribution of fluids to subsequent distribution tray(s).

25 Various objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments, along with the accompanying drawing in which like numerals represent like components.

Brief Description of The Drawing

Figure 1 is a vertical cross-section of a prior art bubble cap.

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Figure 2A is a vertical cross-section of a bubble cap according to aspects of the present invention.

Figure 2B is a horizontal cross-section of the bubble cap taken along the view line 1-1 of Figure 2A.

5 Figure 3 is a vertical cross-section of another bubble cap, having multiple dividers and an increased skirt height due to a decreased cap length.

Figure 4 is a vertical cross-section of another bubble cap, having multiple dividers and an increased skirt height due to an increased riser height.

Figure 5 is a side view of the bubble cap of Figures 2A and 2B showing slide slots.

10 Figure 6 is a perspective view of a distribution plate having multiple bubble caps, showing fluid cross-flow.

Figure 7A is a perspective view of a (delete "pre-" to be consistent with Claim 16?) distribution apparatus having chevron-type vanes.

15 Figure 7B is a vertical cross-section of the (see above) distribution apparatus of Figure 7A taken along line 1-1, and surrounding apparatus.

Figures 7C is a horizontal cross-section of chevron-type vanes in the distribution apparatus of Figure 7B taken along line 2-2.

Figures 8 is a horizontal cross-section of wave plate-type vanes.

Figures 9 is a horizontal cross-section of staggered channel-type vanes.

20 **Detailed Description**

In **Figure 1**, a prior art bubble cap 10 generally comprises a riser 20 and a cap 30 separated by a spacer 40. The bubble cap 10 is attached to a distribution plate 15. The spacer 40 is very small with respect to the lengths of both riser 20 and cap 30, and the skirt height 60 is less than 1.5 inches. The fluid flow path 70 through the bubble cap is generally in the shape of an
25 inverted "U".

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In **Figures 2A and 2B**, a bubble cap 100 generally comprises a riser 120 and a cap 130 separated by a plurality of dividers 140. The bubble cap cooperates with a distribution plate 115 to locally mix the fluids. (As used herein, the term "fluid" means anything that flows, including especially a vapor phase or a liquid phase, or a mixture comprising at least two phases. The term
5 also includes any fluid that is mixed and distributed in a commercial process.)

The riser 120 has a top 122 and a riser height 125 defined by a distance between the top 122 of the riser 120 and the top 116 of the distribution plate 115. The riser 120 also defines an inner passageway 190. Contemplated risers can be formed of any suitable material, including carbon steel, stainless steel and other alloys, plastic, and ceramics, depending in large measure
10 upon the temperature and corrosiveness of the fluids being mixed. Such risers can also have virtually any suitable overall dimensions. The overall shapes are also subject to variation. Although tubular risers having circular horizontal cross-sectional areas are preferred, it is also contemplated to provide tubular risers with elliptical, square, rectangular, or other horizontal cross-sectional areas. Risers need not even have uniform passageways along their length.
15 Preferred risers may also have swirl directors 150 above or within (not shown) the passageways.

The cap 130 has a top 132, a bottom edge 134, and a cap length 135 defined by a distance between the top 132 of the cap 130 and the bottom edge 134 of the cap 130. The cap 130 also has a skirt height 160 defined as the distance between the bottom edge 134 of the cap 130 and the top 116 of the distribution plate 115. Contemplated caps can again be formed of any suitable
20 material, including carbon steel, stainless steel and other alloys, plastic, and ceramics, depending again in large measure upon the temperature and corrosiveness of the materials being mixed. Preferred caps have horizontal cross-sectional areas of similar shape to that of the associated riser, but may also have other shapes. For example, a cylindrical cross-section riser may have a rectangular cross-section cap.

The skirt height 160 is a function of the riser height 125, the cap length 135, and the distance between the top 122 of the riser 120 and the top 132 of the cap 130. Preferred bubble caps have a riser 120 and cap 130 that cooperate to provide a skirt height of no less than 1.5". More preferred bubble caps have a skirt height of at least 1.75 inches, and even more preferred bubble caps have a skirt height of at least 2.0 inches, at least 2.5 inches, at least 3 inches, and at

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least 4 inches. The unusually high skirt heights are preferably achieved by using an especially long riser rather than using an especially short cap, although all combinations are contemplated.

Without being limited to any particular theory or contemplated mode of operation, the present inventors contemplate that a skirt height of no less than 1.5 inches is advantageous because it enhances cross-flow of fluids moving on the top 116 of the distribution plate 115. Hydraulic calculations show that skirt heights up to 3 inches or higher may also be advantageous, depending largely upon the quantity of the liquid phase being conveyed across the top 116 of the distribution plate 115, and subsequently through the space 180 between the riser 120 and the cap 130 and the riser passageway 190. Although not presently considered to be a preferred embodiment, it is also contemplated that the bubble caps on a distribution plate need not all have the same skirt height. For example, some skirt heights may be less than 2 inches while others are more than 2 inches. Alternatively, all skirt heights may be more than 2 inches, and some may be more than 2.5 inches. It may even be advantageous for the bubble caps having relatively higher skirt heights to be positioned around the periphery of the distribution plate, or in some other manner, depending, at least in part, on where the fluids are introduced to the distribution plate.

Alternatively, the slots can be lengthened. Preferred slots can be at least 2.5 inches long, more preferably at least 3.5 inches long, still more preferably at least 4 inches long, at most preferably at least 5 inches long.

The dividers 140 in Figure 2A and 2B preferably span essentially the entire distance from the sidewall of the cap 130 to the sidewall of the riser 120. The dividers are positioned near the top 122 of riser 120. Other embodiments, however, are also contemplated. For example, dividers are currently contemplated to be long enough to have a significant impact on the hydraulics of the fluid flowing in the space 180 between the riser 120 and the cap 130. Preferred dividers 140 impact the fluid hydraulics by having a length of at least 50% of the riser/cap span, preferably 70% of that distance, more preferably 90% of that distance. In an alternative embodiment (not shown), the dividers can extend from the top of the cap all the way to the bottom edge 134 of the cap. The dividers need not be continuous, in that they may be constructed in several shorter dividers, as long as the sum of the length of the dividers is at least 50% of the riser/cap span. Contemplated dividers (not shown) may also be positioned non-vertically such that they impart a swirl to the fluid rising in the space 180 between the riser 120

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and the cap 130. Still further, any suitable number of dividers are contemplated to be utilized in any given bubble cap, including especially from two, three, four, five, or six dividers.

Dividers 140 may be attached to the riser, the cap, or both the riser and the cap. Attachment may be direct or indirect. Some of the dividers may assist in maintaining the positioning of the riser to the cap, and some may not assist very much, or at all, in that regard. Preferred methods of attachment include welding, such as tack-welding, stitch-welding, or any other welding means. Dividers may comprise any suitable material or materials. Swirl director 150 is affixed to the top 122 of the riser 120. The swirl director 150 directs the fluid 170 from a space 180 between the riser 120 and the cap 130 to the riser passageway 190 in a circumferential flow path, which apparently results in a more uniform wetting of the inner wall of the riser 120, and a ring-shaped discharge pattern of the fluid 170, as the fluid 170 exits the riser passageway 190. The swirl director may be continuous with the riser 120, or may be affixed to the riser 120 by welding or any other suitable method. In operation, fluid 170 enters the bubble cap 100 through an opening 117 between the top 116 of the distribution plate 115 and the bottom edge 134 of the cap 130, defined by a skirt height 160. If the bubble cap 100 possesses one or more slots on the side of the cap 130, fluid will also enter the bubble cap 100 therethrough. The fluid 170 then enters the space 180 between the riser 120, the cap 130, and the two dividers 140. The fluid 170 then flows upward through the space 180 and through the swirl director 150 where the fluid 170 is mixed. The fluid then enters the riser 120 and flows downward through the riser passageway 190. The cap length 135 is shorter than the cap length 35 of Figure 1, allowing the skirt height 160 to be longer than the skirt height 60 of Figure 1. In the event that two adjacent bubble caps 100 are at different elevations, due perhaps to a tilted distribution tray 115, the two dividers 140 and the skirt height 160 allow more uniform splitting of the fluid 170 between the two adjacent risers than do two adjacent bubble caps 10 of Figure 1.

The distribution plate 115 is preferably circular, and measures between about 36 inches and about 240 inches in diameter, and between about 0.06 inches and 0.50 inches thick. The size generally depends upon the size of the reactor in which it is utilized. Currently preferred distribution plates are made from stainless steel and other alloys, although any suitable material, including carbon steel, plastics, and ceramics are also contemplated. A typical distribution plate 115 supports between about 60 and about 1200 bubble caps, although lesser or greater numbers

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of bubble caps are also contemplated. The risers 120 are typically rolled into the distribution plate 115, such that the riser passageways 190 coincide with holes 118 in the distribution plate 115.

As depicted in the Jacobs patent referenced above with respect to other bubble caps, the distribution plate 115 may actually comprise a re-distribution plate because chambered mixing and/or rough distribution may be accomplished upstream. Thus, it should be apparent that distribution plate 115 may be placed at any appropriate position with respect to other processes and apparatus in any mixing reactor.

In **Figure 3**, bubble cap 200 is similar to the bubble cap 100 of Figures 2A and 2B, except that the bubble cap 200 has four dividers 240 instead of the two dividers 140. In Figure 3, the four dividers 240 are organized into two sets of two dividers, each set disposed in separate vertical planes within a space 280. Within each set, the two dividers are disposed within one vertical plane within the space 280, and separated within the space 280. As a result, the fluid 270 may pass through the space 280 formed between the riser 220, the cap 230, and past the four dividers 240.

In **Figure 4**, bubble cap 300 is again similar to the bubble cap 100 of Figures 2A and 2B, except that the bubble cap 300 has a cap length 335 that is shorter than the cap length 135, and a riser height 325 that is shorter than the riser height 125. The result is a skirt height 360 that is equal to the skirt height 160 of the bubble cap 100, even though the riser heights and cap lengths are different..

In **Figure 5**, bubble cap 400 has a cylindrically curved side 433, in which are disposed multiple side slots 495. Each of the multiple side slots 495 extends downward to the bottom 434 of the cap 430, such that the slot length 497 of any given slot 495 is the distance from the top 496 to the bottom 434 of the cap 430. The slot elevation 498 is defined as the distance between the top 496 of the slot 495 and the top 416 of the distribution plate 415. Among other things, such side slots 495 allow passage into the bubble cap 400 of a fluid 470 being mixed and distributed.

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The bubble cap 400 of Figure 5 has at least eight slots 495, four of which are shown. The slot length 497 is 2.5 inches, and the slot elevation 498 is 4.5 inches. In alternative embodiments it is contemplated that the slot length 497 could be anywhere from about 1.5 inches to about 12 inches. Slots 495 typically have a generally rectangular shape, although they may have any other suitable shape such as a triangular or other tapering shape, a zigzag shape, and so forth. In **Figure 6**, a distribution plate 516 contains a plurality of bubble caps 500. The fluid 570 flows in a zigzag 550 pattern on the distribution plate 516, with the risers 520 and caps 530 creating a hydraulic resistance to crossflow. A portion 555 of the crossflowing fluid 570 is mixed and distributed by the bubble caps. The plurality of bubble caps 500 may vary in quantity, depending on a variety of factors. Two of the factors are the cap center-to-center spacing, which influences the number of caps per unit of distribution tray area, and the size of the reactor or any other commercial process being used to mix and distribute fluids. Furthermore, the plurality of bubble caps 500 may be distributed on the distribution plate 516 in any manner, preferably in a symmetrical manner to achieve a symmetrical distribution of the fluid. There may or may not be indentations, channels, baffles, or other paths (not shown) disposed in or on the distribution plate 516 to modify the cross-flow 550.

In **Figure 7A, 7B and 7C**, a rough distribution apparatus 600 contains a plurality of chevron-type vanes 610. The vanes are disposed between an outlet of a mixing apparatus 620 and a splash deck 630. The presence of the splash deck 630 forces the fluid exiting the mixing apparatus to flow outward through the passageways 612 formed by chevron-type vanes 610 along paths 613. The splash deck 630 is preferably imperforate, but may contain orifices (not shown) to allow a portion of the fluid to pass downward onto the subsequent distribution tray 650 (which may be the final distribution tray).

By way of reference, Figure 7B depicts catalyst bed 640 below subsequent distribution tray(s) 650, and reactor wall 660.

In a preferred embodiment, the chevron-type vanes 610 are positioned below the substantially imperforate floor of a mixing chamber (not shown), above a substantially imperforate splash deck 630, and surround the outlet orifice(s) 620 of an upstream mixing chamber (not shown). The vane passageways 612 thereby formed cause the fluids flowing therethrough to change directions preferably at least two times and provide the sole means of

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fluid communication between the upstream mixing chamber and the downstream subsequent distribution tray 650. The chevron-type vanes 610 result in a more uniform velocity profile of the fluid exiting the vane passageways 612, thereby providing more effective rough distribution of the fluid to the subsequent distribution tray 650. When used in conjunction with a mixing chamber that swirls the fluids being mixed therein, the chevron-type 610 vanes also serve to reduce the tangential component of the fluid velocity. When arranged in circular layout that is concentric with a central outlet orifice of the mixing chamber, the chevron-type vanes 610 promote a liquid discharge pattern, exiting the vane passageways 612, such that the liquid is supplied to the subsequent distribution tray 650 in an annular ring (not shown). This annular ring supply pattern is an extremely effective method of supplying liquid to the subsequent distribution tray 650, provided that the diameter of the ring produced by the liquid is near optimal. The optimal ring diameter is dependent upon the geometry of the final distribution tray 650 and can be determined by hydraulic calculations. Although chevron-type vanes have been depicted in Figures 7A, 7B, and 7C, other flow redirecting-type vanes have been contemplated. Several examples are depicted in Figures 8 and 9.

In **Figure 8**, wave plate-type vanes 710 are spaced apart to form vane passageways 712, the passageways providing a flow path 713 for fluids to pass therethrough.

In **Figure 9**, staggered channel-type vanes 810 are spaced apart to form vane passageways 812, the passageways providing a flow path 813 for fluids to pass therethrough.

Thus, specific embodiments and applications of mixing and distributing fluids have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

CLAIMS

What is claimed is:

1. A bubble cap comprising:
5 a riser having a top;
a cap having a bottom and at least one side slot, the cap disposed in relation to the riser
such that a fluid flows in a space between the riser and the cap; and
a divider disposed in the space, and extending to a length at least 50% of a distance
measured between the top of the riser and the bottom of the cap.
- 10 2. The bubble cap of claim 1 wherein the length of the divider is at least 70% of the distance
between the top of the riser and the bottom of the cap.
3. The bubble cap of claim 1 wherein the length of the divider is at least 90% of the distance
between the top of the riser and the bottom of the cap.
4. The bubble cap of claim 1 wherein the length of the divider is 100% of the distance
15 between the top of the riser and the bottom of the cap.
5. The bubble cap of claim 1 wherein the divider is attached to the riser.
6. The bubble cap of claim 1 wherein the divider is attached to the cap.
7. The bubble cap of claim 1 wherein the divider is attached to both the riser and the cap.
8. The bubble cap of claim 1 wherein the bubble cap has at least two dividers.
- 20 9. The bubble cap of claim 1 wherein the bubble cap has at least three dividers.
10. The bubble cap of claim 1 wherein the bubble cap has at least six dividers.
11. The bubble cap of claim 1, further comprising a swirl director attached to the riser.
12. A mixing device having a plurality of bubble caps according to claim 1.

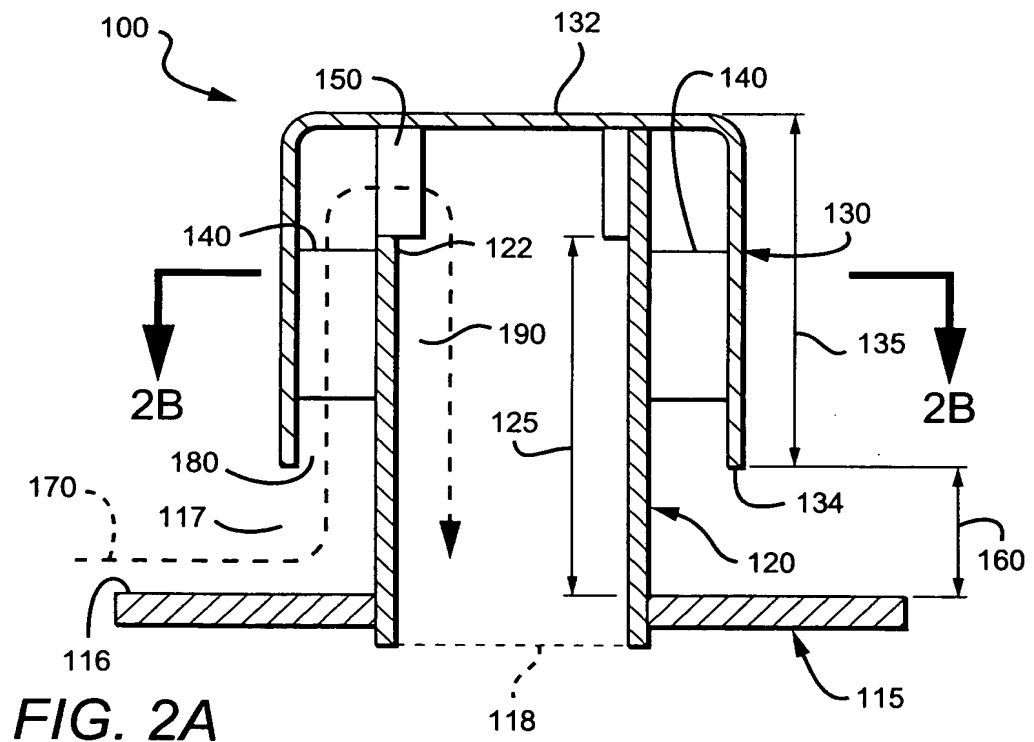
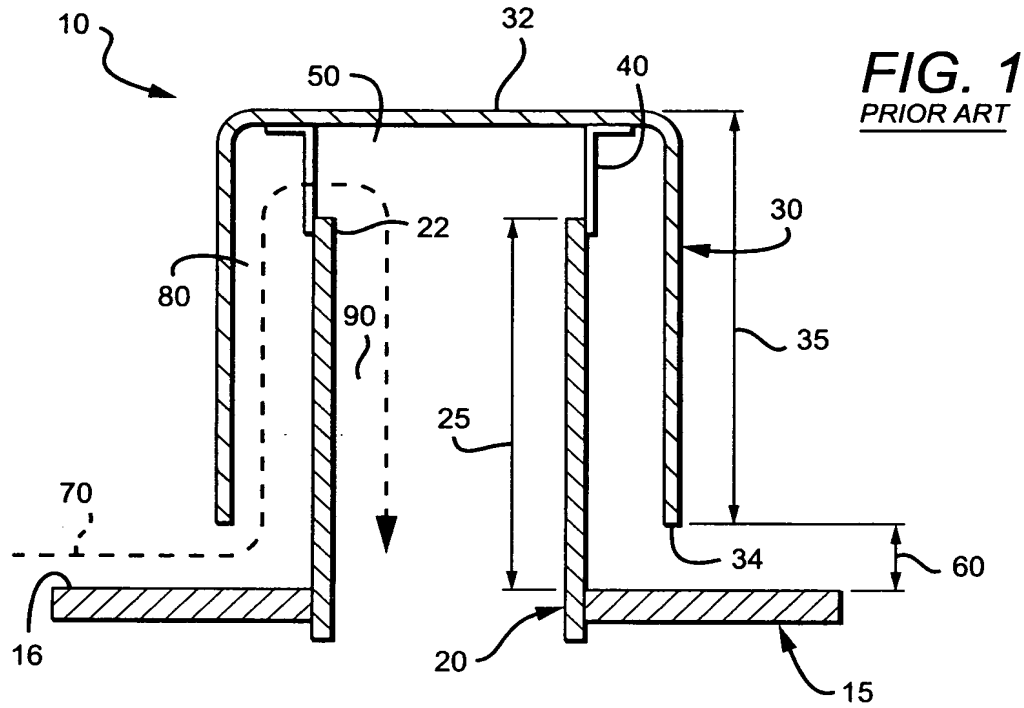
14. A bubble cap, comprising:
a cap with at least one slot and a riser configured to provide the cap with a skirt height of no less than 1.5 inches, disposed such that a liquid fluid and a gaseous fluid flow co-currently upwardly in a space between the riser and the cap.
15. The bubble cap of claim 14, wherein the skirt height is no less than 2.5 inches.
16. The bubble cap of claim 14, wherein the skirt height is no less than 4 inches.
17. The bubble cap of claim 14 wherein the cap has a side that includes at least three slots.
18. The bubble cap of claim 14, wherein the slot has a length of at least 2.5 inches.
19. The bubble cap of claim 14, wherein the slot has a length of at least 3.5 inches.
20. The bubble cap of claim 14, wherein the slot has a length of at least 5 inches.
21. A distribution device comprising:
a plurality of flow-redirecting vanes,
an upper plate having at least one fluid inlet orifice;
a lower plate, the plates disposed in relation to the vanes such that a fluid flows outwardly through a space between the plates and discharging through a fluid outlet orifice defined by the plates and the vanes; and
a distribution tray, disposed below the lower plate.
22. The distribution device of claim 21 wherein the flow-redirecting vanes are chevron-type vanes.
23. The distribution device of claim 21 wherein the distribution tray is a perforated plate.
24. The distribution device of claim 21 wherein the distribution tray is a bubble cap tray.
25. The distribution device of claim 21 wherein the distribution tray is a riser tray.

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ABSTRACT

1 A bubble cap has a riser and a cap, separated by a divider that extends to a length at least 50% of a distance measured between the top of the riser and the bottom of the cap. In another aspect, the riser and cap cooperate to provide a skirt height of no less than 1.5". More preferred
5 bubble caps have a relatively high skirt height or long slit length, or both. In yet another aspect, flow-redirecting vanes and plates (e.g., mixing chamber floor and splash deck) cooperate to provide a rough distribution of fluids to subsequent distribution tray(s).

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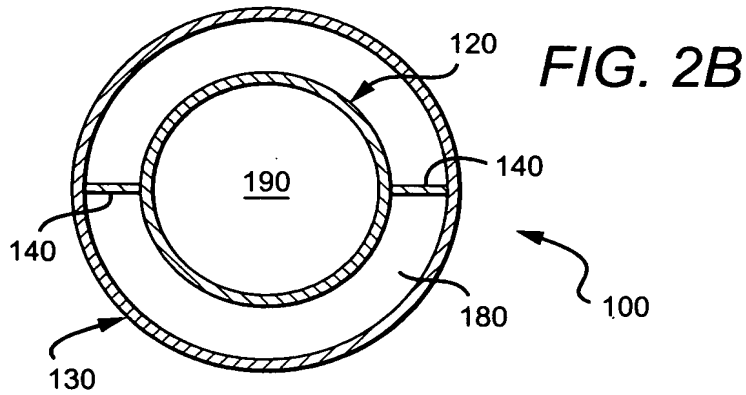


FIG. 3

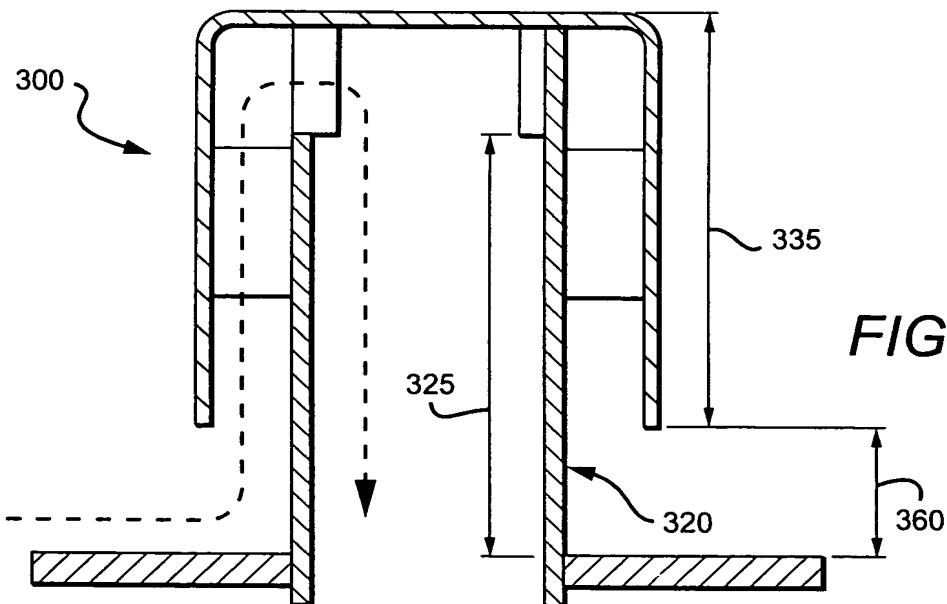
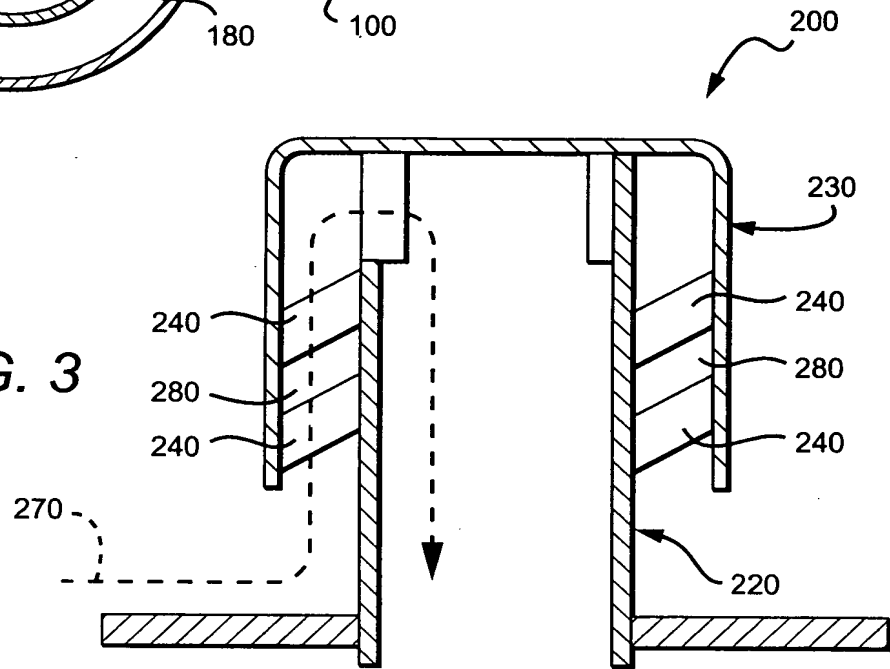


FIG. 4

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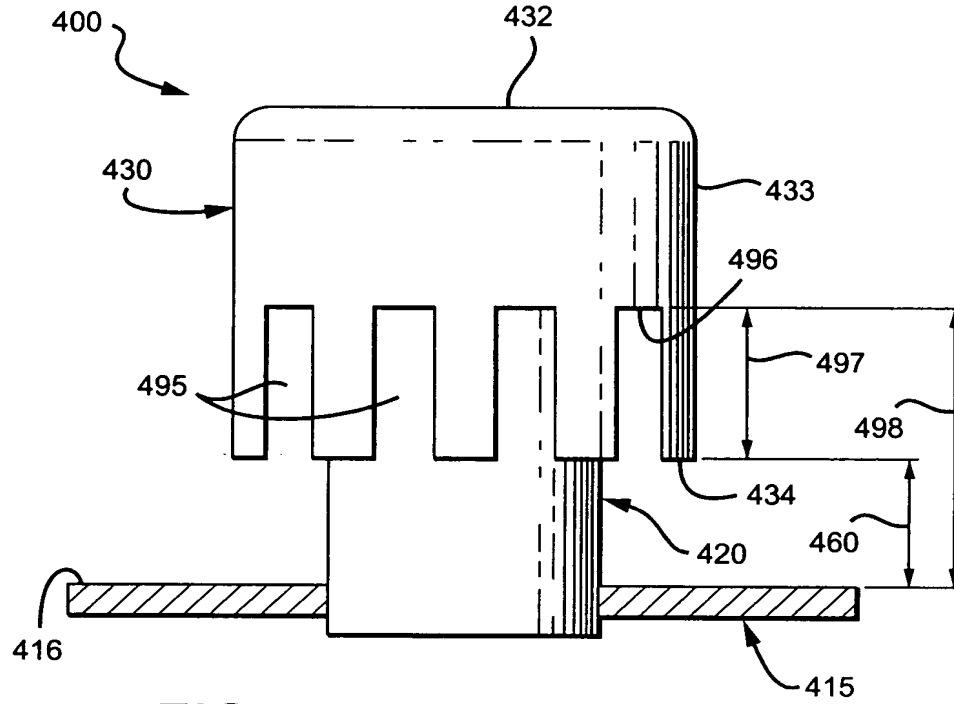


FIG. 5

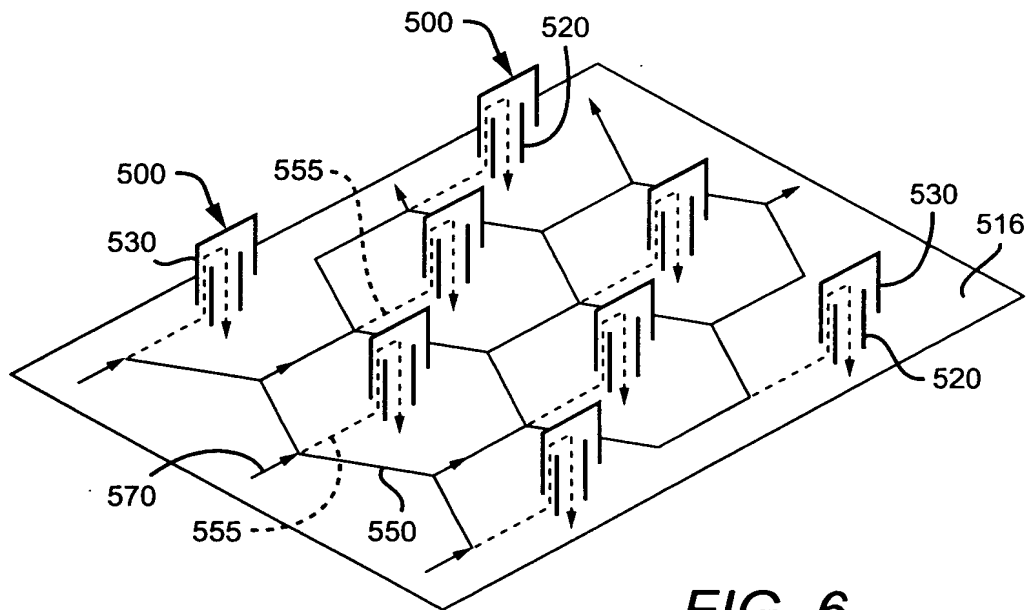
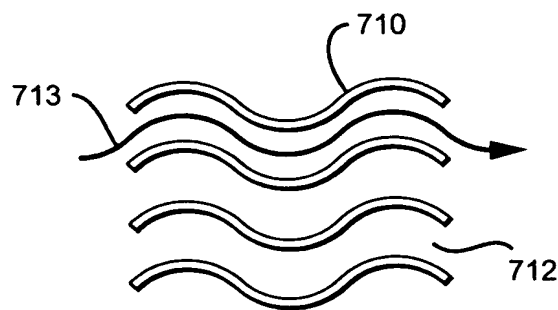
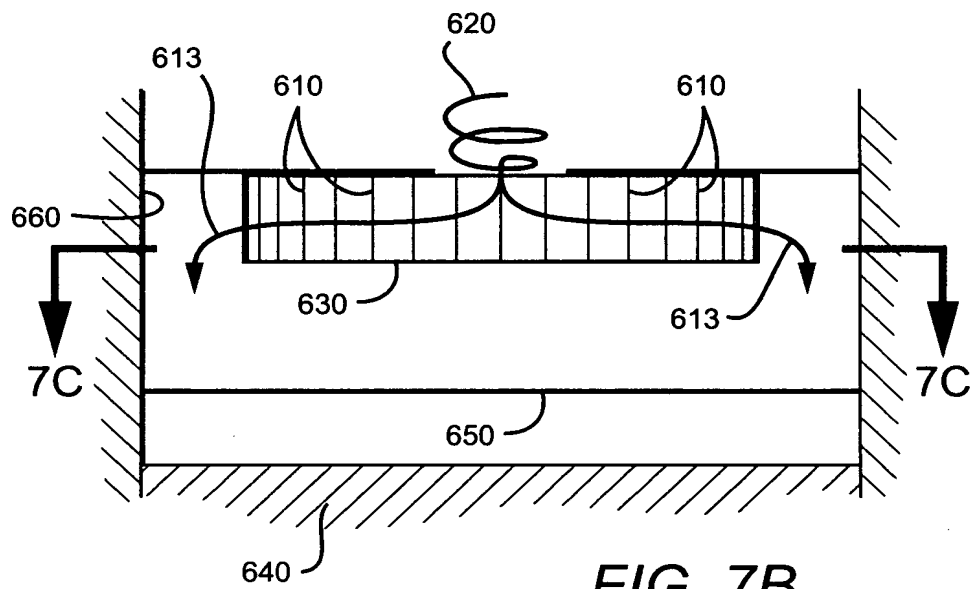
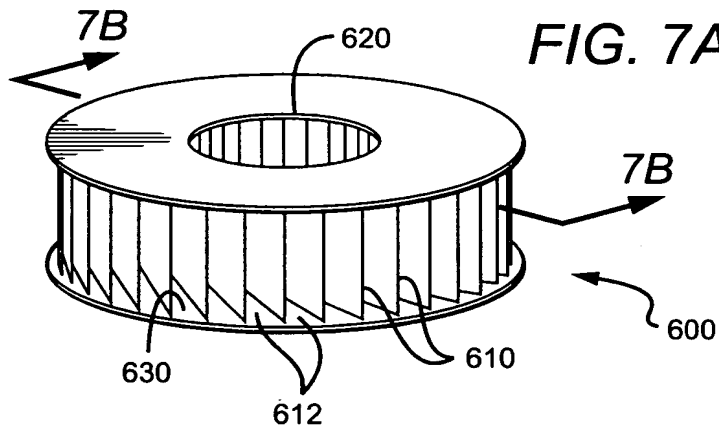


FIG. 6

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FIG. 7C

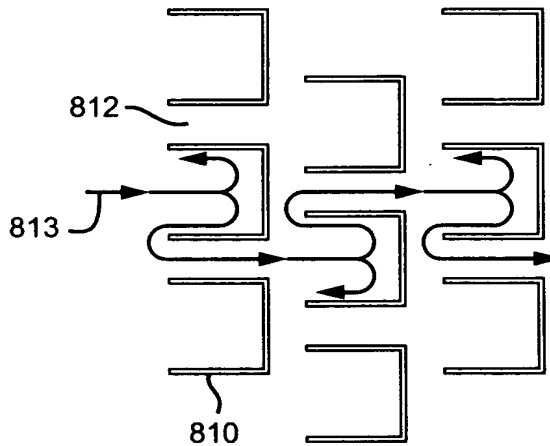
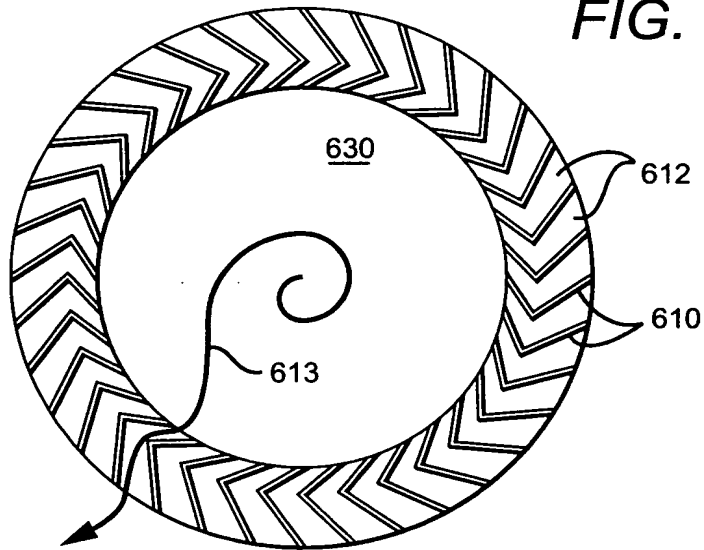


FIG. 9